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Second Generation Models for Strain-Based Design

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Prepared By: Ken Lorang, Team Project Manager and Technical Coordinator
Pipeline Research Council, International
1401 Wilson Blvd., Suite 1101
Arlington, VA 22209
klorang@prci.org

Team Participants:

Yong-Yi Wang, Ph.D.
CRES (Center for Reliable Energy Systems)
6059 Frantz Road, Suite 101
Dublin, OH 43017
ywang@cres-americas.com

Mark Stephens
C-FER Technologies
200 Karl Clark Road
Edmonton, Alberta T6N 1H2
Canada
M.Stephens@cfertech.com

Robin Gordon
Microalloying International
110175 Harwin Drive, Suite 110
Houston, Texas 77036 US
robin@ewimicroalloying.com

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Progress to Date

This project, funded by PHMSA, PRCI, and several other industry partners is aimed at developing strain capacity models and documented procedures for establishing tensile strain capacity limits. Industry partners directly participating in the study include BP, Chevron, Duke, El Paso, Enbridge, ExxonMobil, Gassco, Gaz de France, IPSCO, JFE Steel Corporation, Lincoln Electric, Nippon Steel, Pacific Gas & Electric, Petrobras, Saudi Aramco, SoCalGas, TransCanada PipeLines Limited, TAMSA and Williams.

The primary objectives for the research are to:

- obtain high quality test data to identify the dominant parameters governing the tensile strain capacity of pressurized pipes;
- building on previous work, apply test data to assess the accuracy of existing numerical and engineering models, modify the models to improve accuracy and identify requirements for second generation model development;
- prepare a state-of-the-art guidance document to establish tensile strain limits based on existing SBD models; and
- develop second generation tensile strain limit models and strain-based design (SBD) procedures.

These objectives will be achieved through a well planned and executed experimental testing program from small- to medium- and large-scale, and advanced computational modeling that reflects material's micro-scale response and global structure response.

The project is comprised of the following tasks:

1. Initial Analysis and Test Matrix Development
2. Pipe Acquisition and Specimen Fabrication
3. Small-Scale Material Tests
4. Full-Scale Small Diameter Pipe Tension Tests
5. Analysis of Full-Scale Small Diameter Pipe Tension Tests
6. Full-Scale Large Diameter Pipe Tension Tests
7. Medium-Scale Curved Wide Plate Tests
8. Model Verification and Modification
9. Initial Guidance Document Preparation
10. Progress, Planning and Review Meetings
11. Reporting and Final Presentation
12. Program Management
13. Focused Presentation to PHMSA/OPS

To date, 16 full-scale pipe tension tests and 10 medium-scale curved wide plate tension tests have been carried out on specimens fabricated from small diameter pipes. Preliminary FE analyses were finished on all the completed tests. These tests and analyses have explored the effects of internal pressure, pipe body Y/T, flaw size and temperature on the tensile strain capacity of pipe with circumferential flaws in the pipe body and weld region. The curved wide plate tests were intended to show the degree to which specimen configuration and constraint conditions (i.e. differences between tension loaded pipes and plates) affect strain capacity.

The pipe tests performed to date clearly demonstrate the detrimental effect of internal pressure on the tensile strain capacity. The curved wide plate tests showed that the strain capacity obtained from this test configuration is similar to that obtained for unpressurized pipes. The preliminary FE results indicated that the material property and weld geometry variations need to be considered to understand the test results properly.